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RELIABILITY, VALIDITY AND APPLICATION OF AN IMPROVED SCALE FOR ASSESSMENT OF MOTION SICKNESS SEVERITY

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16. Abstract

Three sea going vessels steamed side-by-side through slight seas off the coast of Oahu, Hawaii. A four-hour octagon was transitted twice each day for three consecutive days while motion sickness symptomatology was recorded from eighteen enlisted men who alternated among the vessels. Dramatic differences in illness severity were obtained whether comparisions were made using objective evidence of vomiting episodes or subjective reporting of symptoms on questionnaires. Reliability of this scoring method was excellent ($r=.95$). In addition to face and construct validity, evidence is presented of the predictive validity of the scoring method in a separate octogonal steaming experiment; using a 95' Coast Guard Patrol Boat in an equivalent experimental paradigm. This study showed significant covariance between the magnitude of motion sickness symptomatology and the encounter direction of the vessel to the primary swell ($p<.01$). Additional, significant correlations were found between sickness severity and test subject concentration, fatigue, urine production and urine specific gravity. The majority of these relationships would not have been disclosed had only the dichotomous criterion of vomit/nonvomit been employed in assessing motion sickness severity. Implications of these data as design criteria for marine vehicles are discussed.

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INTRODUCTION

Nearly all research in motion sickness has assumed that vomiting is the primary indicator of the disease if not the only pathognomic sign. The validity of vomiting as a criterion for motion sickness is undoubtably greater than for the use of any lesser symptom alone; however, vomiting versus not vomiting is a dichotomous criterion experimentally limited in precision and usefulness. Such a measure generally requires large test subject populations for statistical purposes, leads to high test subject attrition rates in repeated measures studies (10, 13) and is relatively insensitive for use in studies of adaptation or antimotion sickness drug effectiveness. For these reasons, along with a desire to find a reliable experimental endpoint short of vomiting, some investigators have sought to scale the severity of motion sickness. A series of studies on motion sickness has been reviewed (14) in which a three point scale was employed; vomiting was graded higher than "nausea without vomiting" which in turn was rated higher than discomfort. Later, Navy scientists at Pensacola developed a 5-point symptomatology scale for research in a Slow Rotation Room (SRR) (8). This scale was subsequently expanded (1, 12) and a score of 4 on a 6-point scale was employed successfully as a practical endpoint for experimentation in which vomiting was to be avoided (18, 19)

The theory behind motion sickness severity scaling is that vomiting while the cardinal sign of motion sickness, is ordinarily preceded by a combination of symptoms (9, 11). After testing 100 subjects to the point of vomiting (4, 5) in the slowly rotating room (SRR), records of the preceding symptomatology were inspected for empirical relationships. Some combination of drowsiness, pallor, nausea, salivation and sweating nearly always preceded vomiting. Additionally, the severity of these

symptoms provided additional clues to the progression of the vomiting response. Other symptoms (e.g. headache, dizziness, anorexia and depression) were less frequent and tended to be more ideosyncratic. This gave rise to the Pensacola scaling method, which along with its variants may be considered to possess both face and construct validity. The predictive validity of this method also has been demonstrated: a) by the differentiation of symptoms in normals from persons with bilateral labyrinthine defects in storm conditions at sea (6) and b) through concordance between laboratory predicted motion sickness incidence, based on vomiting, and motion sickness symptomatology experienced in three different types of aircraft flying through a hurricane (7).

Recently the U. S. Coast Guard, with the cooperation of the U. S. Navy, performed a series of experiments to assess the influence of actual vessel motion upon crew performance, physiology and affective state (15, 16, 17). The present report focuses on the reliability and validity of combining subjective reports of symptomatology with objective reports of vomiting by experimenters in an expanded scale for motion sickness severity assessment.

APPARATUS AND PROCEDURE

Apparatus: Compartments located approximately amidships, which possessed similar physical characteristics with no external visual cues of vessel motion, served as the testing environments for the three vessels; a 378' Coast Guard White High Endurance Cutter (WHEC), a 95' Coast Guard White Patrol Boat (WPB) and a 89' Navy Semi-Submersible Platform (SSP).

All test compartments were fully instrumented to record temperature, humidity and both linear and angular accelerations of the vessel.

Procedure: The three vessels steamed in formation off the coast of Oahu, Hawaii in an octagonal pattern which was repeated twice in eight hours each day for three separate but consecutive days. Each leg of the octagon was approximately 30 minutes in length and differed from adjacent legs by a 45 degree change with respect to the encounter direction of the primary swell. The condition of the seas remained fairly constant at sea state 2 throughout the three day period.

The signs and symptoms of motion sickness have been described in many places (5, 9, 11); however, a worksheet which categorizes them into major and minor indicants appears in Figure 1., and the three degrees of malaise plus "vomiting" and "vestibular sickness" which gave rise to the five point scale used at Pensacola may be seen in the aforementioned figure as well. For the present study this scale was expanded to contain seven points. The new criteria for classification appear in Table I.

TABLE I: DIAGNOSTIC CRITERIA FOR LEVELS OF MOTION SICKNESS SEVERITY

7	-	Experimenter's report of emesis
6	-	Two major symptoms (including retch and subject's report of emesis)
5	-	One major and two minor symptoms
4	-	One major symptom alone or Two minor symptoms or One major and one minor symptom or One minor plus four other symptoms of which 2 (or more) are stomach awareness, sweating, drowsiness or pallor (depending on whether pallor is scored)
3	-	One minor plus other symptoms
2	-	More than two other symptoms are reported
1	-	Any symptom related to motion sickness is reported
0	-	No symptoms are reported

The presence or absence of a sign or symptom of motion sickness was reported by subjects on forms provided in the last five minutes of each steaming leg. These forms queried the subject regarding 34 symptoms normally associated with motion sickness which included cerebral indicants (e.g. headache), gastrointestinal indicants (e.g. nausea, burping, emesis), psychological indicants (e.g. anxiety, depression, apathy) and other less characteristic items such as "discomfort". A response was required for each symptom using a rating of "none", "slight", "moderate" or "severe". The number of occurrences of a symptom in the previous twenty-five minutes was reported as appropriate. Responses from the subject's questionnaire were transcribed by one of the investigators (RSK) onto the worksheet shown in Figure 1 and then after discussion of the scoring criteria shown in Table I, were scored independently by two investigators (RSK and MEM). In addition to the independent scoring by the two investigators, a third rater (DAA), unsophisticated regarding motion sickness symptomatology, and fourth a computer subroutine (ADP), generated two additional sets of scores using the diagnostic criteria specified in Table I. A second group of scores was generated using a six-point scale (experimenter's report of emesis was eliminated) by the same group of raters for later comparison. These four sets of scores were examined for interrater reliability via correlation analysis for both the seven (with vomiting) and six-point (without vomiting) scoring systems.

The seven-point scaling method was then utilized to score raw symptomatology data collected aboard the 95' WPB during a pilot study (15) conducted prior to the three vessel comparison. The scores were analyzed statistically in order to determine possible influence of

DIAGNOSTIC CATEGORIZATION WORK SHEET

Name	Pathognomic Signs	Major Signs and Symptoms						Minor Signs and Symptoms				
	Vomit	Nausea II or III	Increased Salivation II or III	Pallor III	(cold) Sweating III	Drowsiness III	Retch	Nausea I	Increased Salivation I	Pallor II	(cold) Sweating II	Drowsiness II
1.												
2.												
3.												
4.												
5.												
6.												
7.												
8.												
9.												
10.												
11.												
12.												
13.												
14.												
15.												
16.												
17.												
18.												
19.												
20.												
21.												
22.												

	Predisposing Factors			Concordance of Signs & Symptoms	Noncompletion Warranted	Diagnosis
	Degree Unfit 0,1,2,3	Subject's Concern 0,1,2,3,4	Subject's Prediction -1,0,-1			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						

Diagnostic Terms

Vestibular Sickness (VS)

Vomiting or
two major symptoms or
one major and two minor symptoms

Malaise III

One major or
two minor symptoms or
one minor and two other symptoms

Malaise I

Any subjective symptom or
any sign usually associated with
any subjective symptom.

Malaise II

All others

Note: In addition, an occasional diagnosis of "Anxiety Reaction" may be made when signs and symptoms warrant

	Other Signs						Signs of Anxiety		Other Symptoms: Gastrointestinal				Mental		Cerebral			
	Pallor I	Sweating I	Drowsiness I	Characteristic Facies	Increased Yawning	Restrict Head Movement	Aerophagia	Character Facies	Stomach Awareness	Anorexia	Burping	B.M. Desire	Depression	Apathy	Headache	Dizziness	Vertigo	General Discomfort
1.																		
2.																		
3.																		
4.																		
5.																		
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21.																		
22.																		

FIGURE 1. Diagnostic Categorization Worksheet

vessel encounter direction to the primary swell upon motion sickness severity. Emesis incidence and motion sickness symptomatology scores were compared with other physiological and psychological variables.

Subjects: Eighteen young males (22.1 ± 5.05 yrs) were selected from the ship's company of the participating Coast Guard High Endurance Cutter for voluntary participation in this study. Subjects were in good health, of average height (1.79 ± .06 m), and weight (74.61 ± 7.16 kg), and none had the habit of smoking. No individuals were allowed to participate if they reported a history of either high or low susceptibility to motion sickness. Motion sickness history questionnaires indicated the subjects' susceptibility to be: a) about average for their age group (4), b) comparable to the susceptibility of a group of Naval Aviators (5) but c) less than for college students in general (3).

All subjects were provided the same diet with all stimulants (e.g. coffee, tea, cola drinks, etc.) and depressants (e.g. alcohol) restricted 24 hrs prior to and throughout the period of testing.

Liberty for the subjects was regulated in order to assure compliance with dietary restrictions as well as the attainment of adequate rest. Special liberty was provided to the subjects for their participation upon completion of the study.

RESULTS AND DISCUSSION

Reliability: Interrater reliabilities for scoring the subject's self-report of symptoms on a 6-point scale, which does not incorporate the experimenter's report of observed emesis, are provided below in TABLE II.

TABLE II: INTERRATER RELIABILITIES USING A SIX-POINT SCALE

(WITHOUT VOMITING)

	MEM	DAA	ADP
RSK	.867	.851	.861
MEM		.961	.951
DAA			.961

(N=864)

The correlation coefficients are all high (mean r=.905) and statistically significant ($p < .01$). The highest reliability occurred between the inexperienced rater (DAA) and the computer (ADP). The lowest was between the developer of the scoring system (RSK) and others.

Table III shows interrater reliabilities for a seven-point scale i.e., with the experimenter's recorded observation of emesis included. Reliabilities are high showing essentially common variance. This resulted in an increase in the mean correlation from r=.905 to r=.956 for Tables II and III respectively and implies the intrarater relisbilities as shown along the diagonal in parenthesis.

	RSK	MEM	DAA	ADP
RSK	(.98)	.95	.96	.96
MEM		(.97)	.95	.95
DAA			(.98)	.97
ADP				(.98)

(N=864)

TABLE III: INTERRATER RELIABILITIES USING A SEVEN-POINT SCALE

(WITH VOMITING)

The correlation between motion sickness scores generated with and without the experimenter's report of vomiting showed high within rater relationships (RSK r=.962; MEM r=.848; DAA r=.964 and ADP r=.954).

Validity: A point-biserial correlation (r_{xy}) was then calculated for each of the subjects who vomited. Each half-hour time frame was scored 0-1 depending on whether he vomited versus his reported symptomatology for that half hour (0-6). Each of these within subject correlations (r) was significant and the average was $\bar{r}$=.63 providing validation for the symptom scoring approach. In addition, four summary measures of motion sickness within the three vessels over three days (i.e. N=9) were employed: 1) number of people vomiting 2) total number of vomiting episodes 3) average time of first vomiting response 4) average symptomatology rating. Each subject served as his own control by alternating over the three vessels. The first three measures were to provide further validity checks for the symptomatology rating.

Each measure showed clear differences between the vessels. For the first measure, all but one subject (n=18) vomited aboard the WPB, only one subject vomited aboard the SSP and no reports of emesis occurred aboard the WHEC. The second measure showed that 83 episodes of emesis were observed aboard the WPB, one on the SSP and no episodes on the WHEC. The third measure showed that the average time to emesis was clearly shortest aboard the WPB. Finally, as can be seen in Table IV, the average level of motion sickness symptomatology experienced aboard the WPB was substantially greater than on either of the two other vessels. This relationship held true for each day and over the entire three day period even when the experimenter's reports of vomiting were omitted from the scoring. Stated differently, experimenter's reports of

vomiting (with) provided the same information as the scored subjective reports of symptomatology (without). In addition, the intercorrelations of three of the four measures were significant ($P<.01$, $\bar{r}=.90$); the exception being average time of first vomiting response ($r=.25$).

Application: With the validity and reliability of the Motion Sickness Symptomatology Severity (MSSS) scale established, a real world experimental comparison of MSSS scores and emesis data was sought. For this purpose raw symptomatology questionnaire data and recordings of emesis episodes were obtained from a pilot study (15) conducted just prior to the three vessel comparison study.

The pilot study was conducted essentially in the same manner as the more comprehensive study with a few exceptions: a) only one vessel was utilized, the WPB, b) two seperate but consecutive steaming days followed a dockside control day, c) six male WPB regular crewmembers served as test subjects for the three day study (24 ± 7.21 yrs; 1.77 ± .06 m; 74.09 ± 10 kg;) d) motion sickness susceptibility was average.

The number of episodes of emesis plotted as a function of octagonal steaming leg is presented in Figure 2. Octagonal steaming legs which possessed head sea components (2, 3 and 8) produced on the average 3.5 vomiting episodes per leg while those legs which allowed the WPB to steam with the primary swell (5, 6 and 7) produced only 0.7 episodes per leg. A difference that was statistically significant ($P=.05$). (Legs 1 and 4 represented transitions complicated by previous legs and were omitted.)

Similar relationships but more dramatic and regular were found between head versus following seas when MSSS scores (rather than emesis)

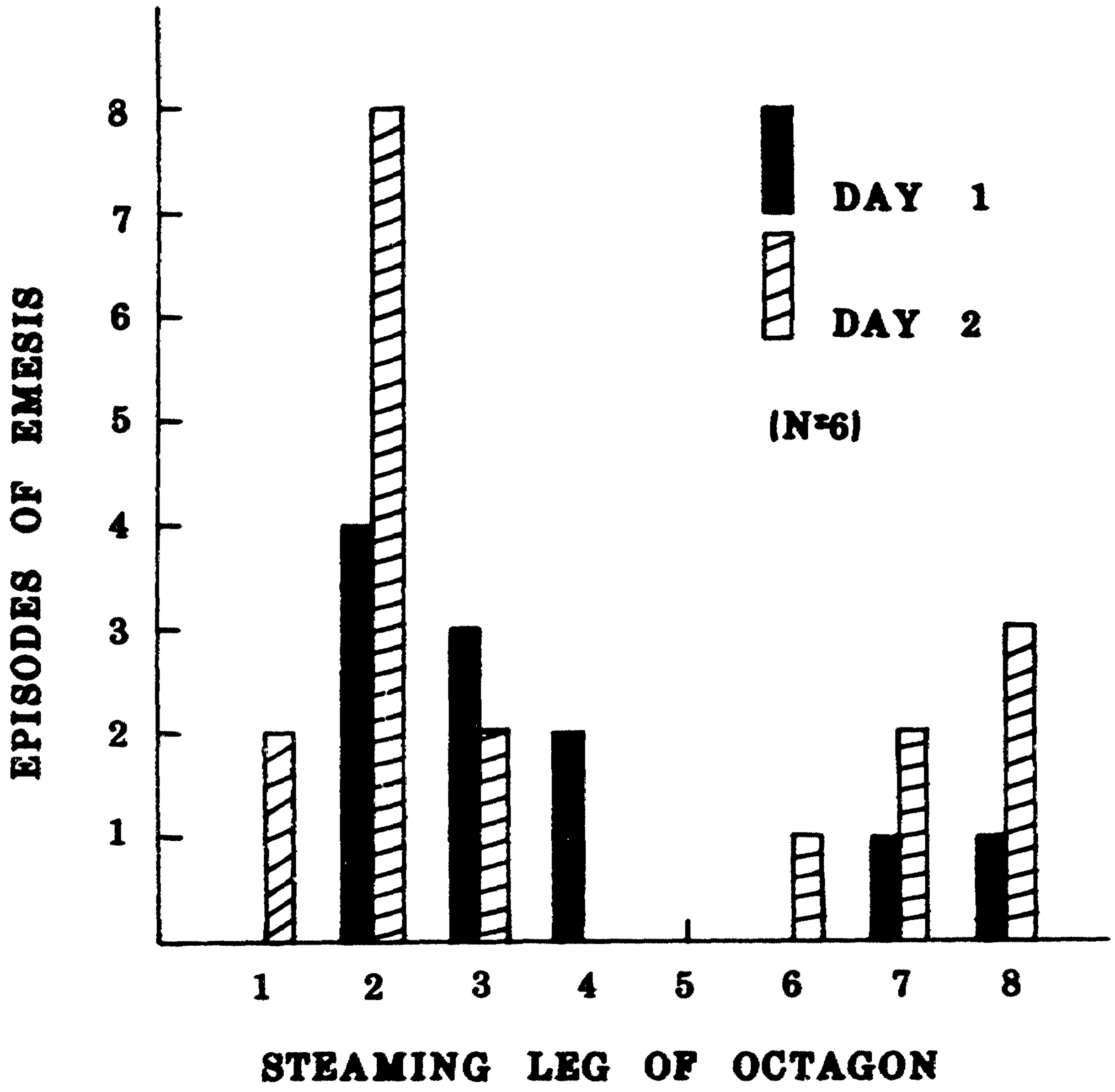


FIGURE 2. Episodes of Emesis per Octagonal Steaming Leg

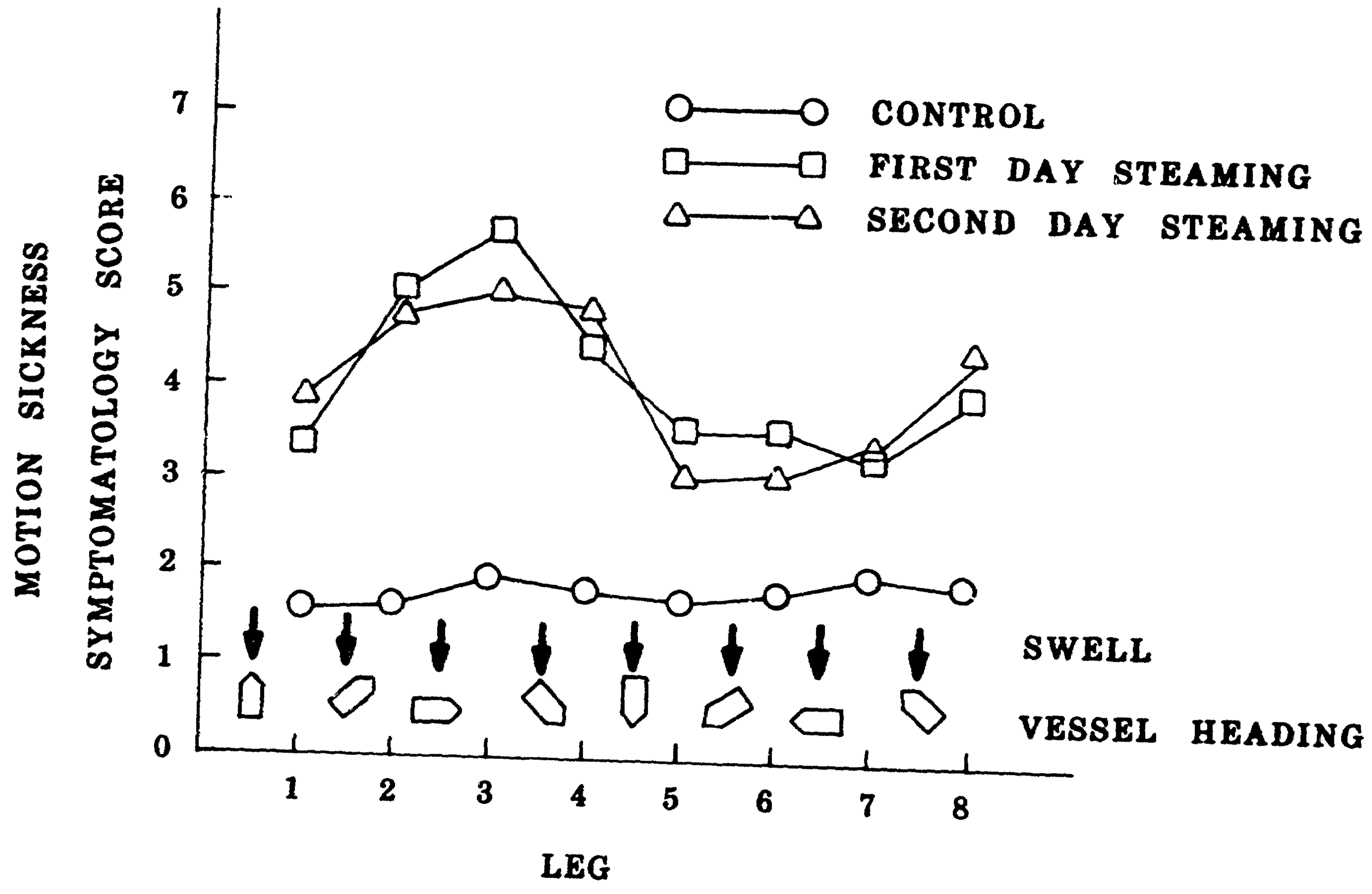


FIGURE 3. Motion Sickness Symptomatology Severity per Octagonal Steaming Leg

were plotted as a function of octagonal steaming leg as shown in Figure 3. The difference between head sea symptomatology levels (5.00) and scores obtained from legs with following seas ([illegible].45) resulted in differences which were clear cut ($p < .001$) and more readily seen than had been obtained with vomiting data alone. It should be noted that motion sickness symptoms do not usually occur immediately in response to a stimulus and so the MSSS score for a particular leg has been offset slightly. It is helpful to consider that some symptoms may have particularly long latencies and it is possible that motions during Leg 1 could influence symptoms at the end of Leg 1 or even Leg 2. With this in mind it is still clear that the encounter direction of the steaming vessel to the primary swell (1 - steaming directly into the swell, 2 - port bow seas, 3 - port beam seas, 4 - port quartering seas, 5 - following seas, 6 - starboard quartering seas, 7 - starboard beam seas, and 8 - starboard bow seas) has a direct bearing upon the incidence of emesis.

It is interesting to note that as the average level of symptomatology per subject per day remains approximately equivalent from Day 1 (4.22 ± 1.11) to Day 2 ($4.14 \pm .84$), the incidence of vomiting per subject per day increases from Day 1 (1.83 episodes/ subject) to Day 2 (3.0 episodes/subject). This increase in vomiting incidence, however, falls short of significance ($p = .11$). Because the pilot study had no objective measurements of sea state or vessel motions, one can only speculate as to the divergence of the two indicants of motion sickness. Possibly the act of vomiting became more socially, psychologically or physically acceptable to the subjects after the first day's steaming and possibly the sea conditions were more conducive.

TABLE IV: MOTION SICKNESS SYMPTOMATOLOGY SEVERITY SCORES FOR 3 VESSELS

	WPB Without Vomiting Reports	WPB With Vomiting Reports	SSP	WHEC	$\bar{X}$
Day 1	4.77	4.95	2.18	2.42	3.18
Day 2	5.68	5.72	1.86	2.25	3.27
Day 3	4.52	4.81	1.32	1.21	2.56
$\bar{X}$	4.99	5.16	1.89	1.96	3.00

TABLE V: CORRELATION MATRIX COMPARING MSSS AND EMESIS WITH PHYSIOLOGICAL AND PSYCHOLOGICAL INDICES SENSITIVE TO VESSEL MOTION

	1	2	3	4	5	6	7	8	9	10
1. MSSS		.45	-.65*	-.69**	.33	-.17	-.29	.83**	-.50**	-.07
2. Emesis			-.45	.49	.47	.38	-.20	.29	-.54**	.31
3. Urine Production				-.95**	-.06	.31	.14	-.76**	.11	.03
4. Urine Sp. Grav.					.16	-.10	-.26	.85**	-.04	-.03
5. 17-OHCS						-.04	-.13	.08	-.30	-.17
6. Catecholamines							.02	.03	.33	.41
7. Navigation Task								-.29	.04	.64**
8. Fatigue									-.18	.11
9. Concentration										.24
10. Skepticism										

*$p < .05$

**$p < .01$

Emesis incidence and MSS scores were analyzed for possible correlations with other physiological and psychological parameters which were found to be significantly influenced by vessel motions encountered aboard the WPB (15). The results, presented in Table V, indicate that the dichotomous variable of emesis is far less fruitful than symptomatology scores for pointing out possible interrelationships between the other variables. Significant correlations were found between symptomatology scores and subject urine production, urine specific gravities, fatigue and concentration. Emesis incidence, on the other hand, was found to correlate significantly with only one variable, subject concentration, although relationships to variables significantly related to MSSS were in the predicted direction.

The fact that emesis incidence produced few correlations with other variables, including motion sickness symptomatology scores, is probably due to the small test subject population in the pilot study (N=6) and the relatively sporadic quality of the vomiting episodes. A binary index with a relatively small subject population does not lend well to correlation analysis. A major advantage of the MSSS over the vomit/no vomit index is that the continuous scale is more amenable to correlational analysis.

CONCLUSION

The motion sickness symptomatology scale developed for this study has proven to be both a valid and reliable tool for the assessment of motion sickness onset and severity, and is not hampered by the degree of autonomy or sophistication of scoring personnel. It correlates well with reports of vomiting alone ($\bar{r}=.63$) and also two of three valid

indications of motion sickness (the number of people vomiting, and total number of emesis incidences) covary (r=.90) with the MSSS. Although these latter indicants are valid they are not as advantageous as the MSSS from a statistical standpoint because the MSSS can provide more continuous information about subject state during pre and postemesis periods.

The use of the MSSS scoring method has provided significant real world evidence that the direction of swell encounter by a surface vessel, such as the WPB, plays an important role in the provocation of motion sickness. When the vessel was steaming into the seas, theoretically producing higher motion frequencies and greater accelerations than if the vessel were riding with the seas, motion sickness severity was greatest. The operational significance of this factor, shown in Figure 3, should not be overlooked because it can suggest countermeasures for the seasickness problem.

For example, steaming patterns employed for search and rescue operations in a given sea spectra could be planned to minimize the amount of time spent heading into the primary swell. If steaming into the primary swell for long periods of time can not be avoided, then speeds should be reduced to lower the frequency and acceleration response of the vessel.

Similar actions can be taken with amphibious landing vehicles (LVA's) which presently steam small circles behind the mother ship while other LVA's load for the beach assault. If the seas are not great enough to pose a broaching problem, the operators may be able to effectively reduce the incidence of motion sickness by steaming in an oval or race track pattern in which the long axis of the pattern parallels the trough of the primary swell.

In addition to the influence of the seas upon the motions of the vessel, the design characteristics of the three surface vessels studied produced dramatically different levels of illness. The 89' Navy experimental vessel (SSP), which represents a radical change from traditional monohull ship design, produced only very minor levels of sickness which were equivalent to those levels produced by the much larger and heavier Coast Guard White High Endurance Cutter (378' WHEC).

It is clear that sea state, vessel encounter direction to the primary swell and hull design characteristics play a major role in the provocation of motion sickness aboard marine vehicles. The specific frequencies and accelerations in the various dimensions which act on the vestibular and other sensory systems to produce illness, however, remain ill defined (2, 10). Research is necessary to determine what degrees of motion sickness are responsible for unacceptable decrements in human performance, physiological and psychological state. Questions remain concerning the relationship between severity of illness and habituation rate as well. Moreover, the obvious question of potential sex differences is not presently being addressed in any research at present of which we are aware.

Hopefully, the use of this improved methodology for the assessment of motion sickness severity will aid scientists and engineers in providing answers to the above questions and thereby improve human habitability aboard present and future marine vehicles.

REFERENCES

1. Graybiel, A., Wood, C. D., Mil'er, E. F., II, and Cramer, D. B. 1968. Diagnostic criteria for grading the severity of acute motion sickness. Aerospace Medicine, 39: 453-455.

2. Guignard, J. C. and McCauley, M. E. 1977. Motion sickness incidence induced by complex periodic waveforms. Proceedings of the Human Factors Society. 197-201.

3. Hardacre, L. E., and Kennedy, R. S. 1963. Some issues in the development of a motion sickness questionnaire for flight students. Aerospace Medicine. 34: 401-402.

4. Kennedy, R. S., and Graybiel, A. 1963. A comparison of the susceptibilities of three groups of naval aviation personnel to symptomatology of motion sickness. Presented at the American Psychological Association Meeting, Philadelphia, PA.

5. Kennedy, R. S. and Graybiel, A. 1965. The Dial Test: A standardized procedure for the experimental production of canal sickness symptom-atology in a rotating environment. Research Project MR005.13-6001, Report No. 113, NSAM 930.

6. Kennedy, R. S., Graybiel, A., McDonough, R. C. and Beckwith, F. D. 1968. Symptomatology under storm conditions in the North Atlantic in control subjects and in persons with bilateral labyrinthine defects. Acta Oto-laryngologica. 66: 533-540.

7. Kennedy, R. S., Moroney, W. F., Bale, R. M., Gregoire, H. G. and Smith, D.G. 1972. Motion sickness symptomatology and performance decrements occasioned by hurricane penetration in C-121, C-230 and P-2 Navy aircraft. Aerospace Medicine 43: 1235-1239.

8. Kennedy, R. S., Tolhurst, G. C., and Graybiel, A. 1965. The effects of visual deprivation on adaption to a rotating environment. NSAM-918, Pensacola, FL: Naval School of Aviation Medicine.

9. Lentz, M. and Guedry, F.F. 1978. Motion sickness susceptibility: A comparison of laboratory tests. Aerospace, Environmental and Space Medicine. 49 (11): 1281-1288.

10. McCauley, M. E., Royal, J. W., Wylie, C. D., O'Hanlon, J. F., and Mackie, R. R. 1976. Motion Sickness Incidence: Exploratory studies of habituation, pitch and roll, and the refinement of a mathematical model. Human Factors Research, Inc., Goleta, CA, TR 1733-2.

11. McNally, W. J. and Stuart, J. E. 1942. Physiology of the labyrinth reviewed in relation to seasickness and other forms of motion sickness. War Medicine. 2: 683-771.

12. Miller, E. F. and Graybiel, A. 1974. Comparison of five levels of motion sickness severity as the basis for grading susceptibility. Aerospace Medicine. 45 (6): 602-609.

13. O'Hanlon, J. and McCauley, M.E. 1974. Motion Sickness incidence as a function of the frequency and acceleration of vertical sinusoidal motion. Aerospace Medicine. 45: 366-369.

14. Wendt, G. R. 1968. Experiences with research on motion sickness. Fourth Symposium on the Role of Vestibular Organs in Space Exploration. Pensacola, Florida: NASA Special Publication No. SP-187.

15. Wiker, S. F. and Pepper, R. L. 1978. Changes in crew performance, physiology and affective state due to motion aboard a small monohull vessel. Coast Guard Tech Report No. CG-D-75-78.

16. Wiker, S. F., Pepper, R. L. and McCauley, M. E. 1979, in preparation.

17. Wiker, S. F. and Pepper, R. L. 1979, in preparation.

18. Wood, C. D. 1970. Anti-motion sickness therapy. In A. Graybiel (Ed.) Fifth Symposium on the Role of the Vestibular organs in Space Exploration. Pensacola, Florida: NASA Special Pub. No. SP-314.

19. Wood, C. D., and Graybiel, A. 1970. Evaluation of antimotion sickness drugs. Aerospace Medicine. 41 (8): 932-933.

APPENDIX

MOTION SICKNESS QUESTIONNAIRE *

1. general discomfort — None___ Slight___ Moderate___ Severe___
Remarks______________________

2. fatigue — None___ Slight___ Moderate___ Severe___
Remarks______________________

3. boredom — None___ Slight___ Moderate___ Severe___
Remarks______________________

4. mental depression — None___ Slight___ Moderate___ Severe___
Remarks______________________

5. drowsiness — None___ Slight___ Moderate___ Severe___
Remarks______________________

6. headache — None___ Slight___ Moderate___ Severe___
Remarks______________________

7. "fullness of the head" — None___ Slight___ Moderate___ Severe___
Remarks______________________

8. blurred vision — None___ Slight___ Moderate___ Severe___
Remarks______________________

9. a) dizziness with eyes closed — None___ Slight___ Moderate___ Severe___
Remarks______________________

b) dizziness with eyes open — None___ Slight___ Moderate___ Severe___
Remarks______________________

10. loss of direction — None___ Slight___ Moderate___ Severe___
Remarks______________________

11. a) salivation increased — None___ Slight___ Moderate___ Severe___
Remarks______________________

b) salivation decreased — None___ Slight___ Moderate___ Severe___
Remarks______________________

12. sweating None___Slight___Moderate___Severe___

Remarks______________________________

13. faintness None___Slight___Moderate___Severe___

Remarks______________________________

14. aware of breathing None___Slight___Moderate___Severe___

Remarks______________________________

15. stomach upset None___Slight___Moderate___Severe___

Remarks______________________________

16. nausea None___Slight___Moderate___Severe___

Remarks______________________________

17. burping None___Slight___Moderate___Severe___

Remarks______________________________

18. loss of appetite None___Slight___Moderate___Severe___

Remarks______________________________

19. increased appetite None___Slight___Moderate___Severe___

Remarks______________________________

20. desire to move bowels None___Slight___Moderate___Severe___

Remarks______________________________

21. vomiting None___Slight___Moderate___Severe___

Remarks______________________________

22. confusion None___Slight___Moderate___Severe___

Remarks______________________________

23. apathetic Very___Somewhat___No___

Remarks______________________________

24. queasy Yes___No___Remarks______________________

25. relaxed Yes___No___Remarks______________________

26. clammy Yes___No___Remarks____________________

27. yawning Often___Occasionally___None___

Remarks____________________

28. smoking more than usual Yes___No___Remarks____________________

29. physically tired Very___Somewhat___No___

Remarks____________________

30. mentally tired Very___Somewhat___No___

Remarks____________________

31. crave certain foods Yes___No___Type____________________

32. claustrophobic Yes___No___Remarks____________________

33. bothered by personal habits of partner Yes___No___Remarks____________________

34. irritable Very___Somewhat___No___

Remarks____________________

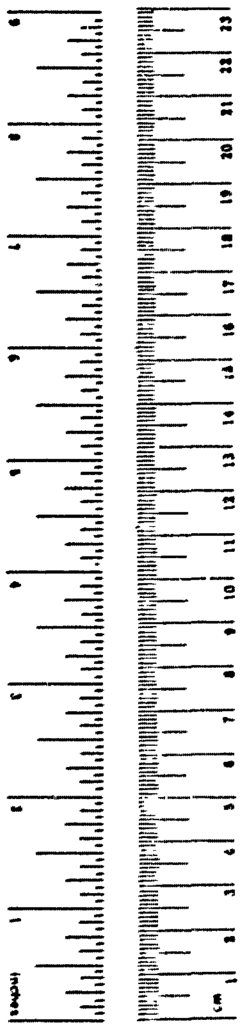
* Taken from Abrams, C., Earl, W. K., Baker, C. H., and Buckner, D. N. "Studies of the effects of sea motion on human performance". Tech Report 796-1. Office of Naval Research, 1971.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F